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(54) **WOVEN IRRIGATION TUBING, APPARATUS AND METHOD OF MAKING SAME**

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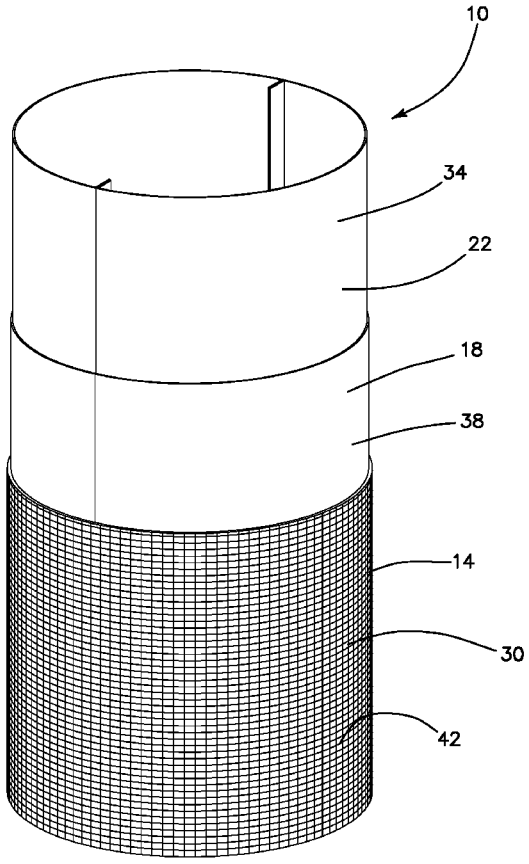
(57) **ABSTRACT**

Woven irrigation tubing comprising a woven, extrusion coated & laminated tube formed of a high density polyethylene (HDPE) outer layer, a low density polyethylene (LDPE) middle layer and a linear low density polyethylene (LLDPE) inner layer. The finished tubing is treated for ultraviolet resistance. The tubing is tied off at a distal end with a proximal end connected to a pressurized irrigation source. Watering holes are created in the tubing at spaced intervals and the resulting water streams are directed into parallel plowed furrows. The tubing is completely recyclable. The tubing is formed by manufacturing tape for the woven outer tubing cover, stretching the tape along its length to strengthen it, weaving the outer layer from the tape, flattening the woven outer layer, extrusion coating each surface of the outer layer with LDPE, laminating the LLDPE inner layer to the LDPE, reversing and winding the tubing for storage and distribution.



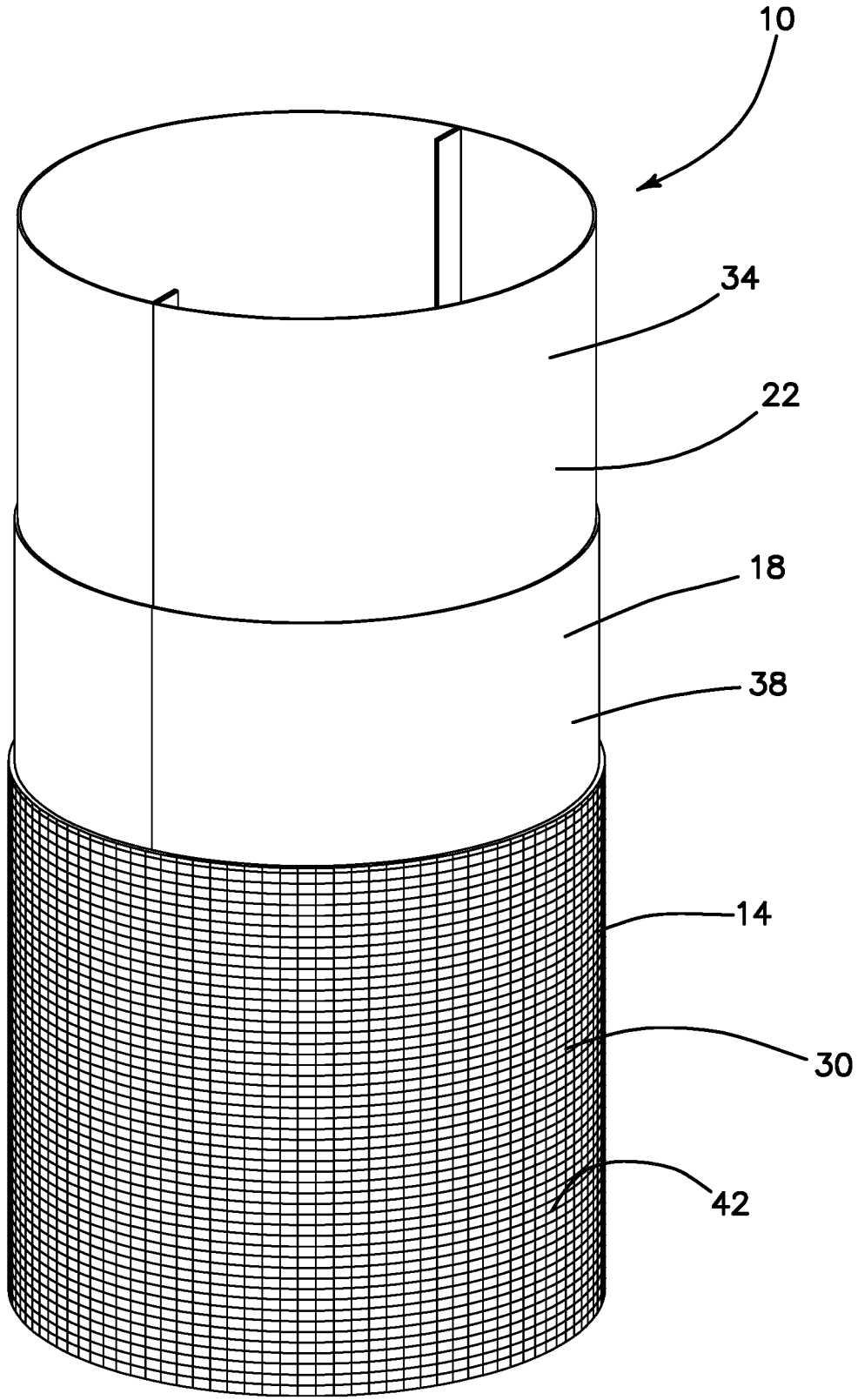



FIG. 1

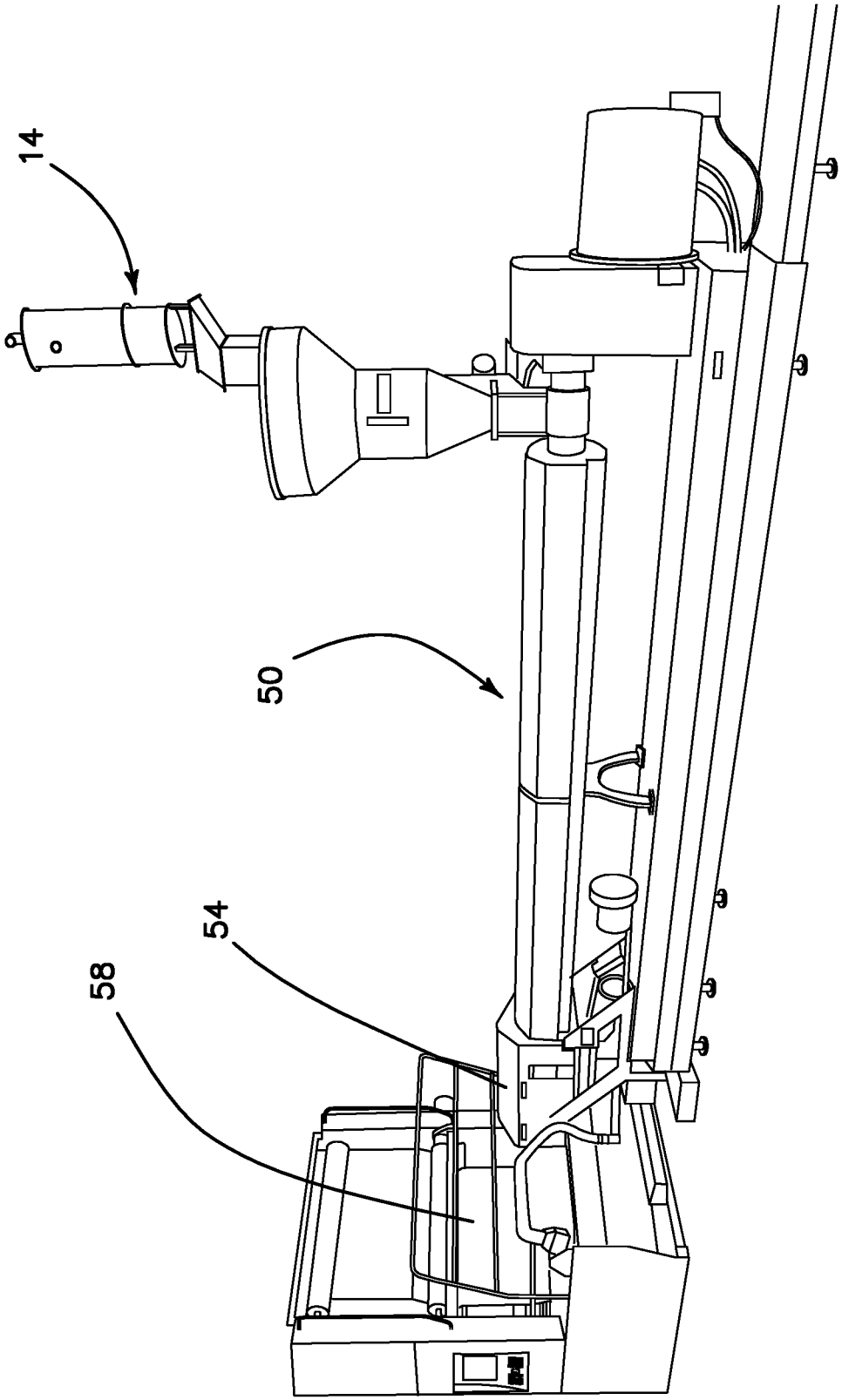



FIG. 2

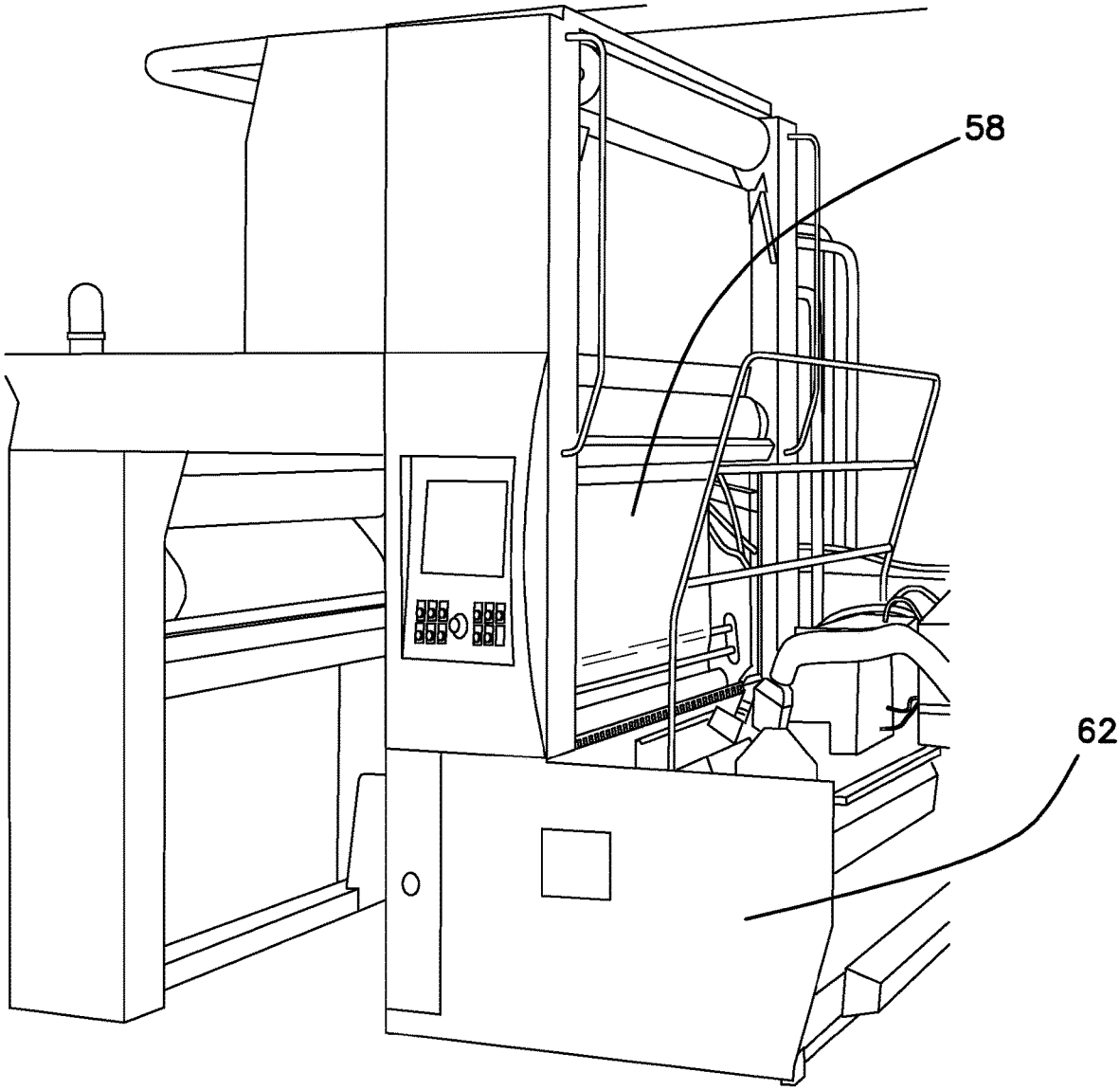



FIG. 3

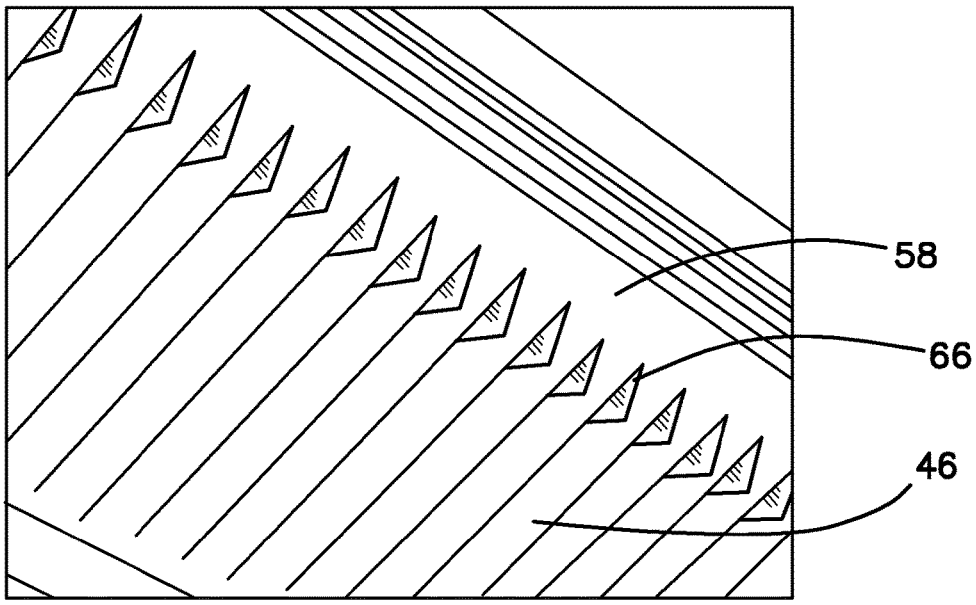



FIG. 4

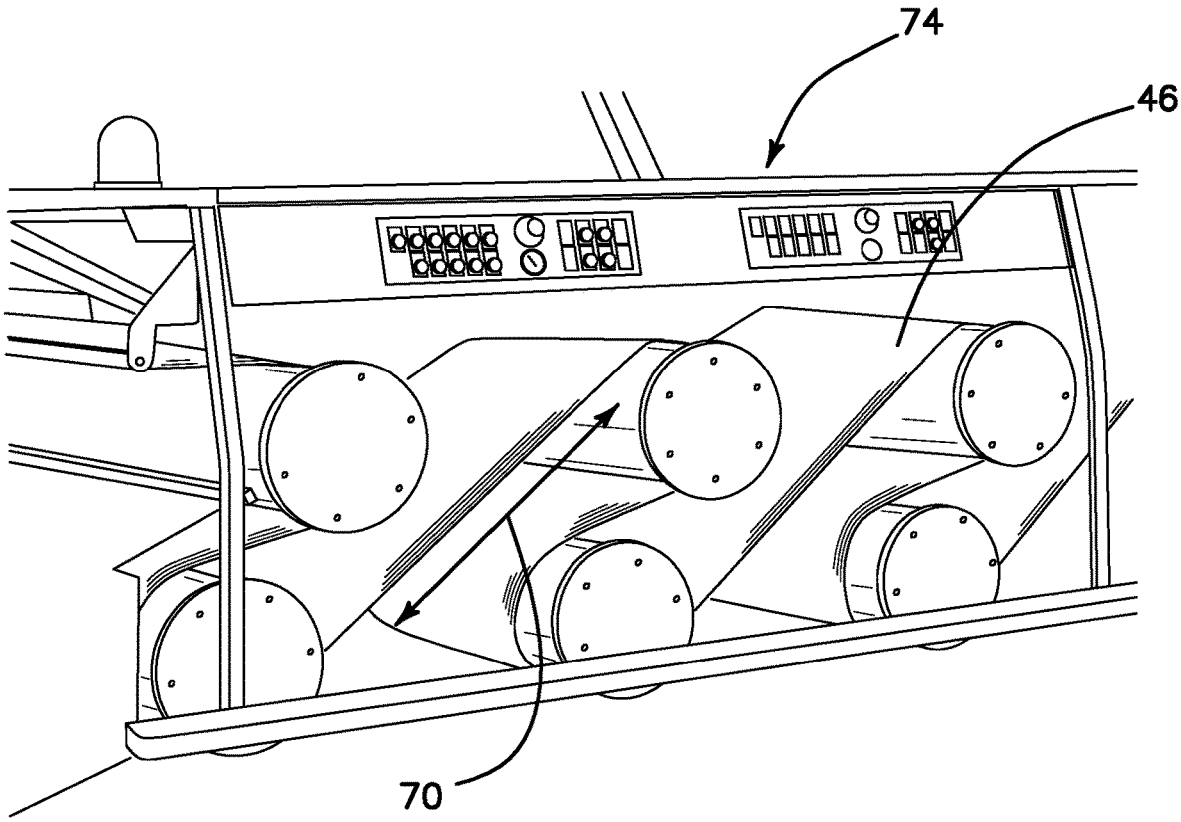



FIG. 5

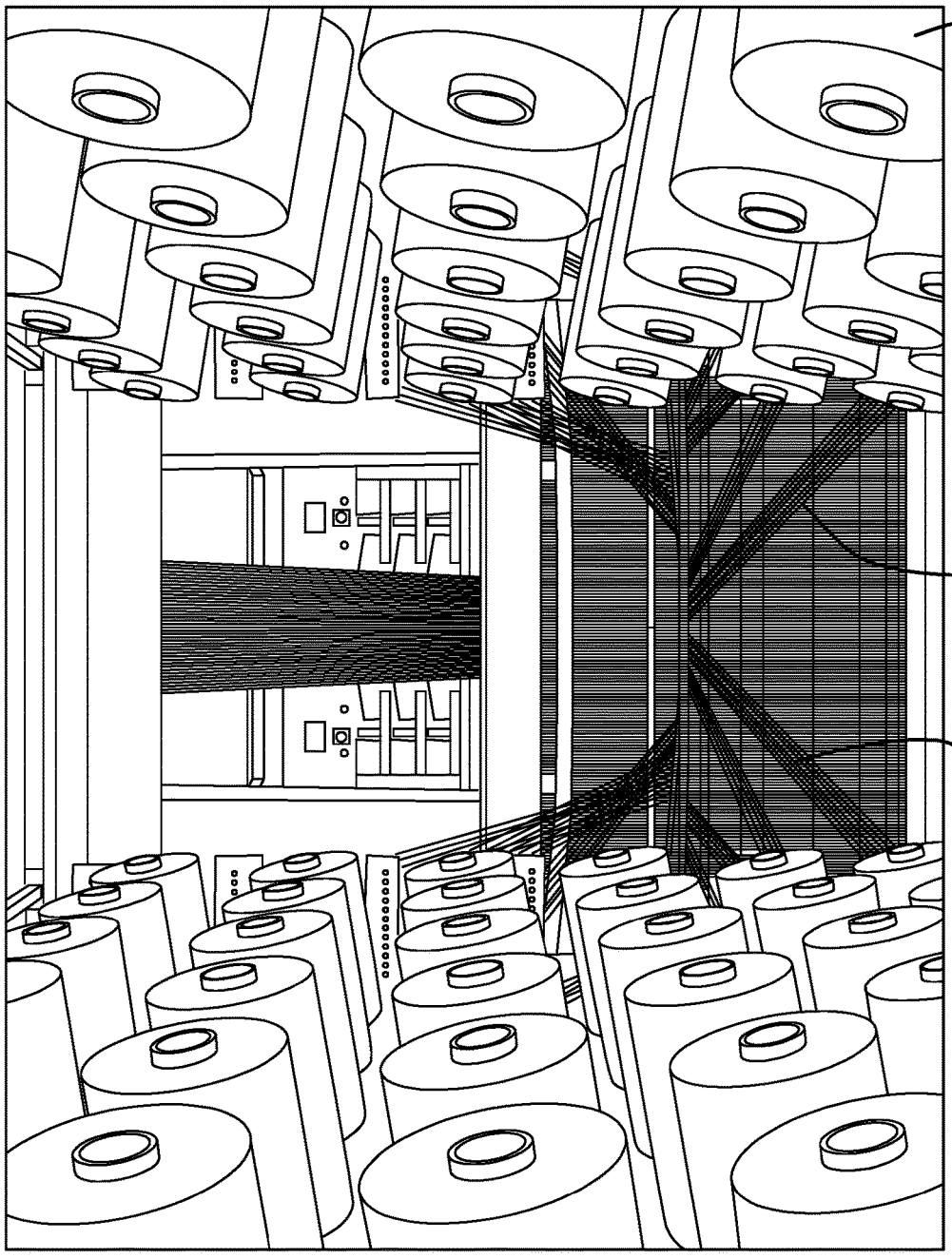



FIG. 6

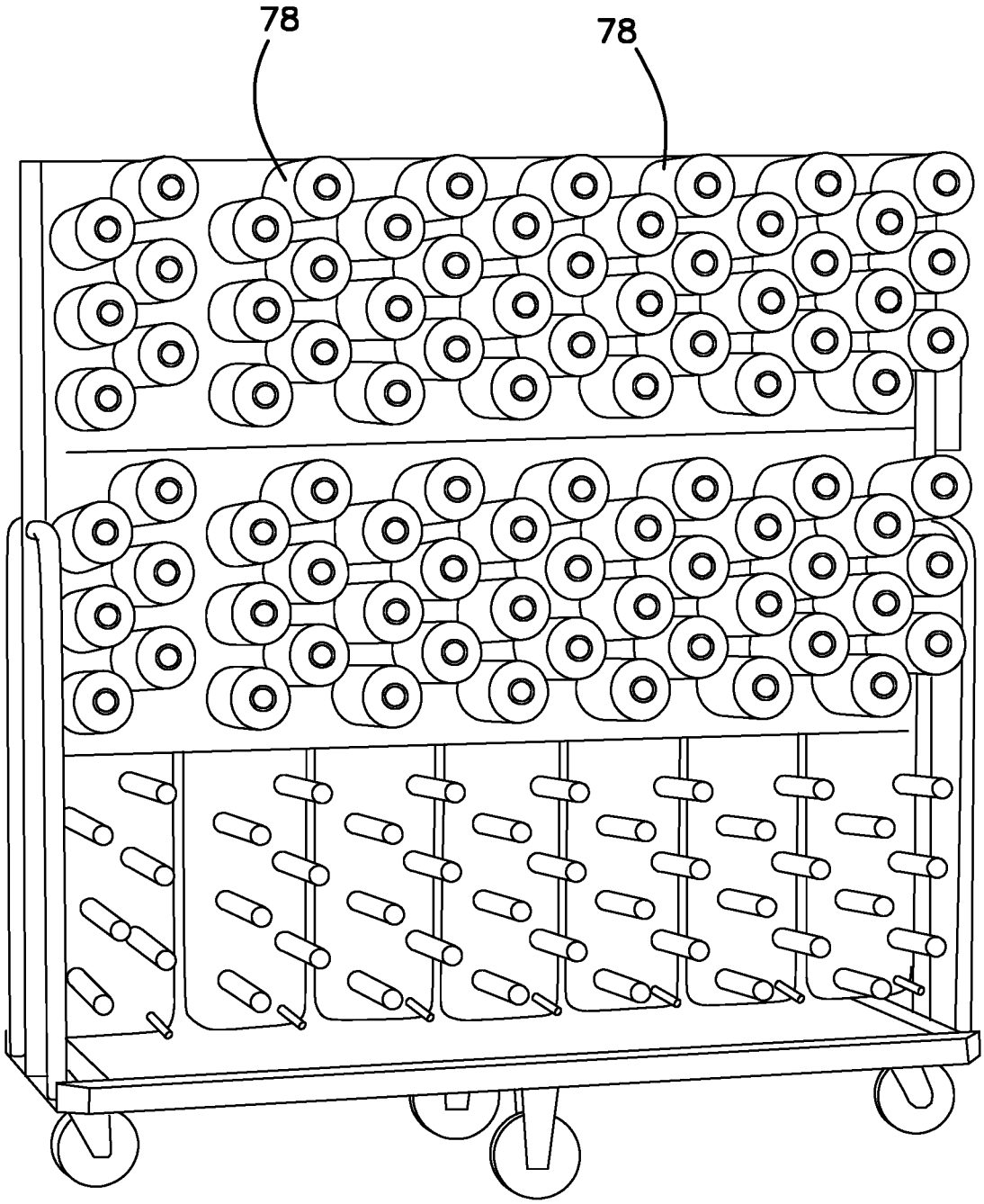



FIG. 7

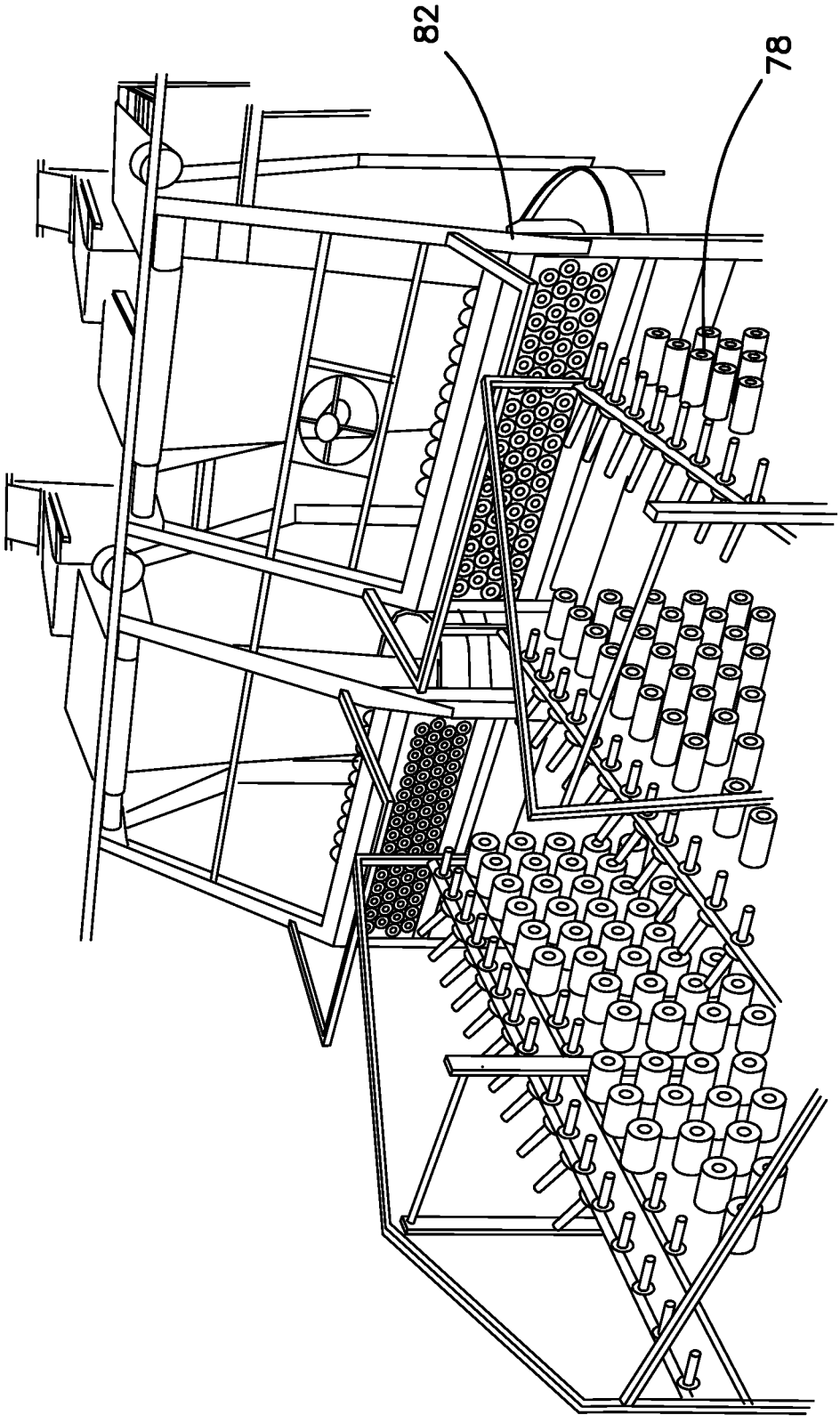



FIG. 8

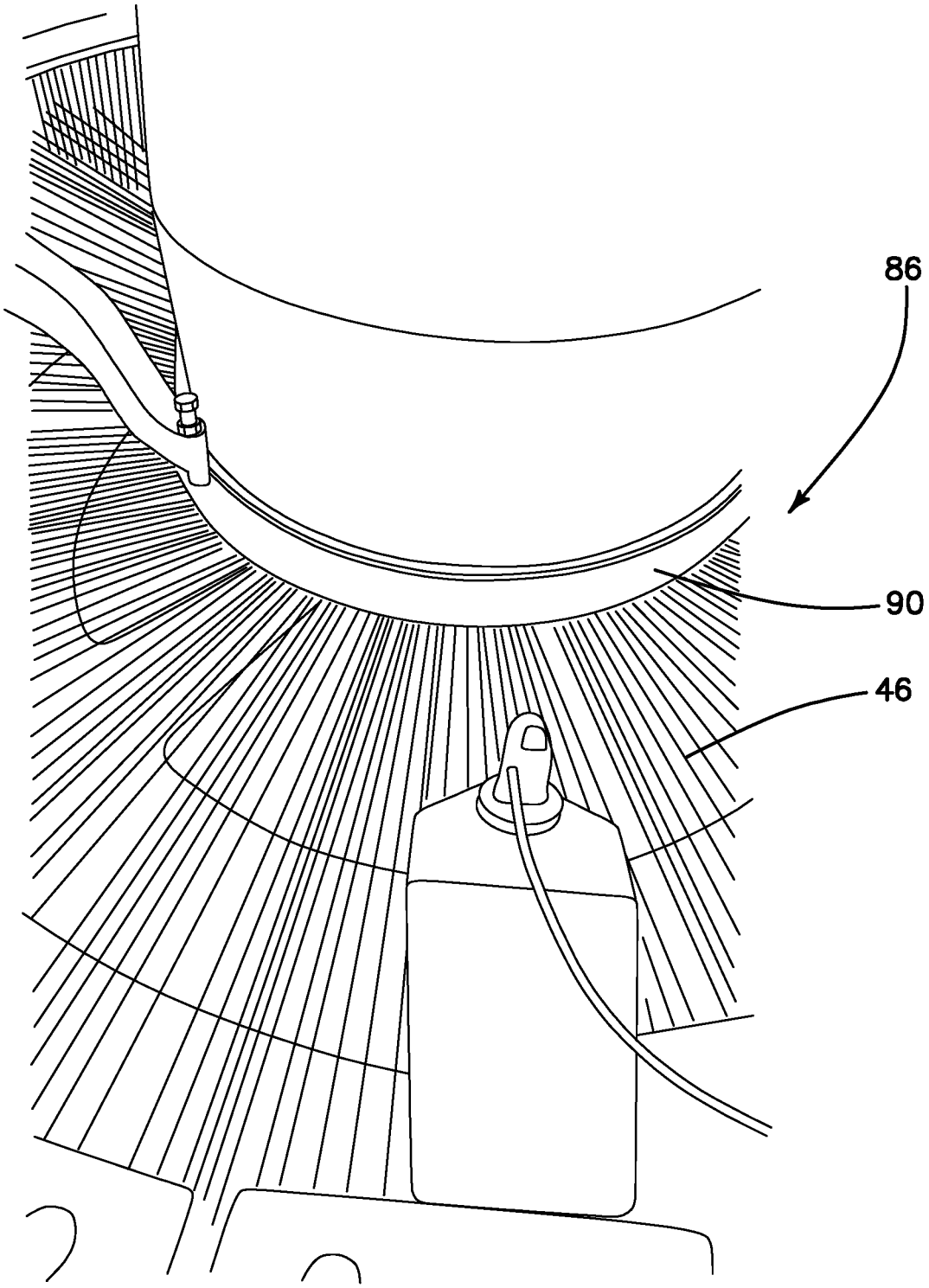



FIG. 9

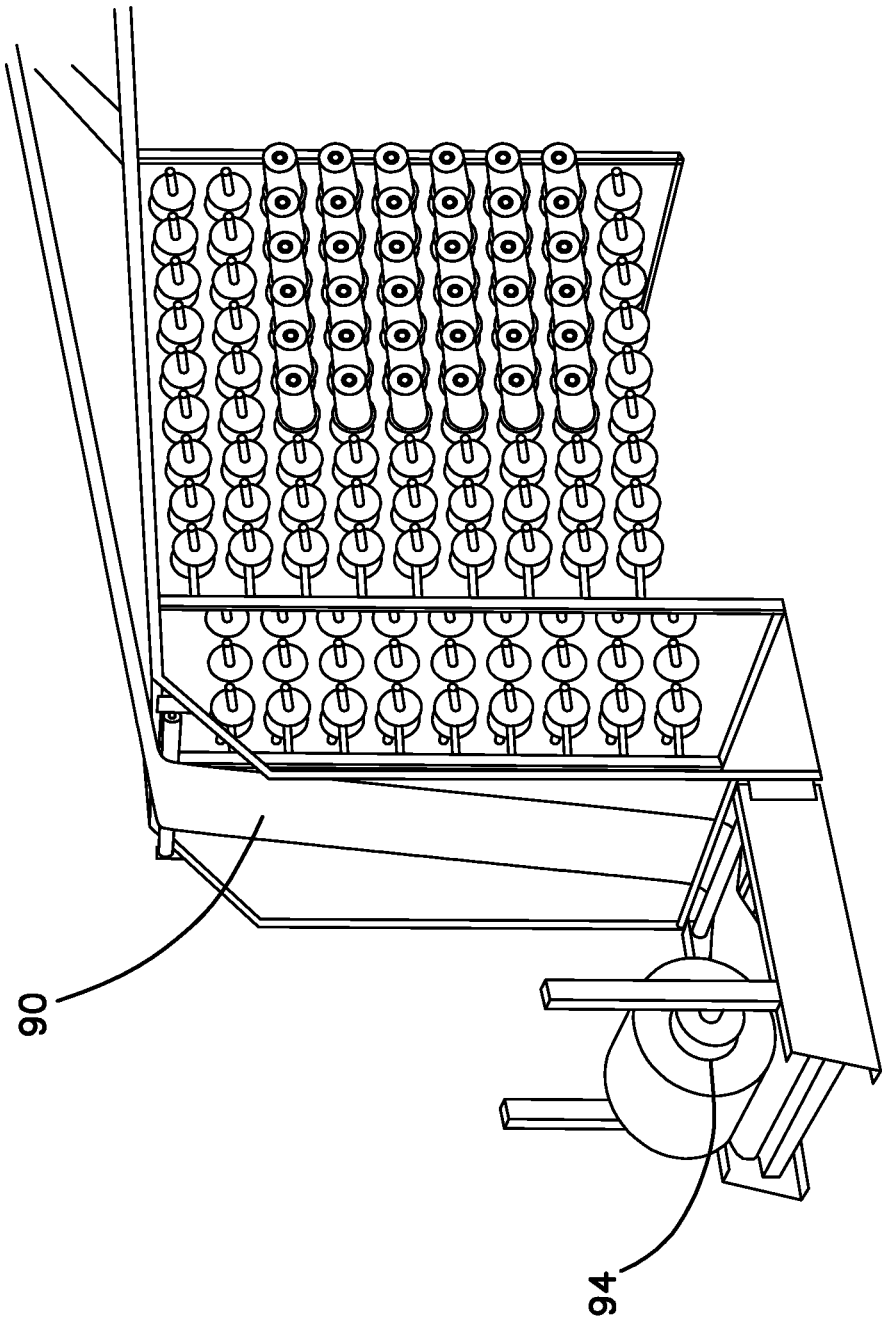



FIG. 10

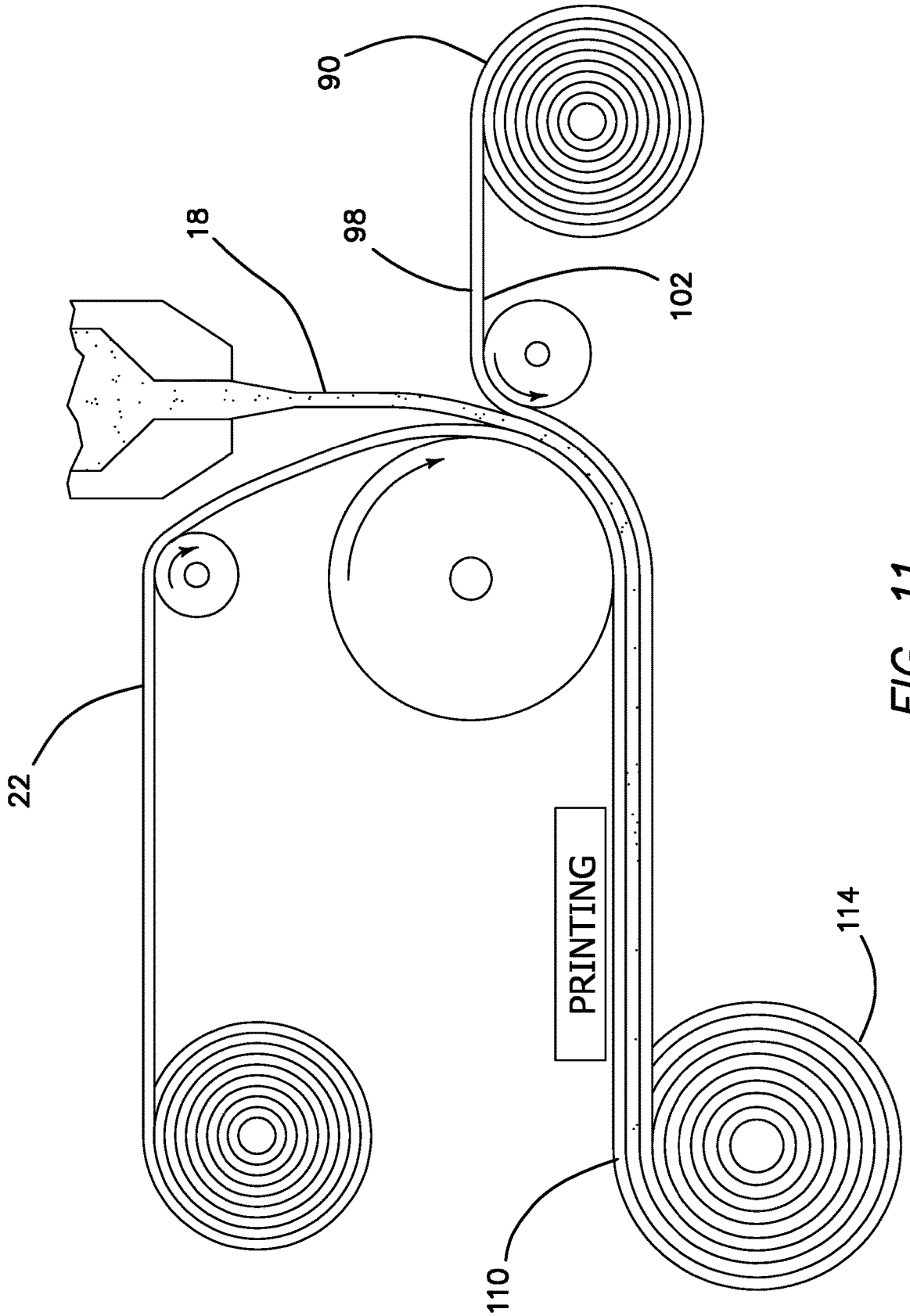



FIG. 11

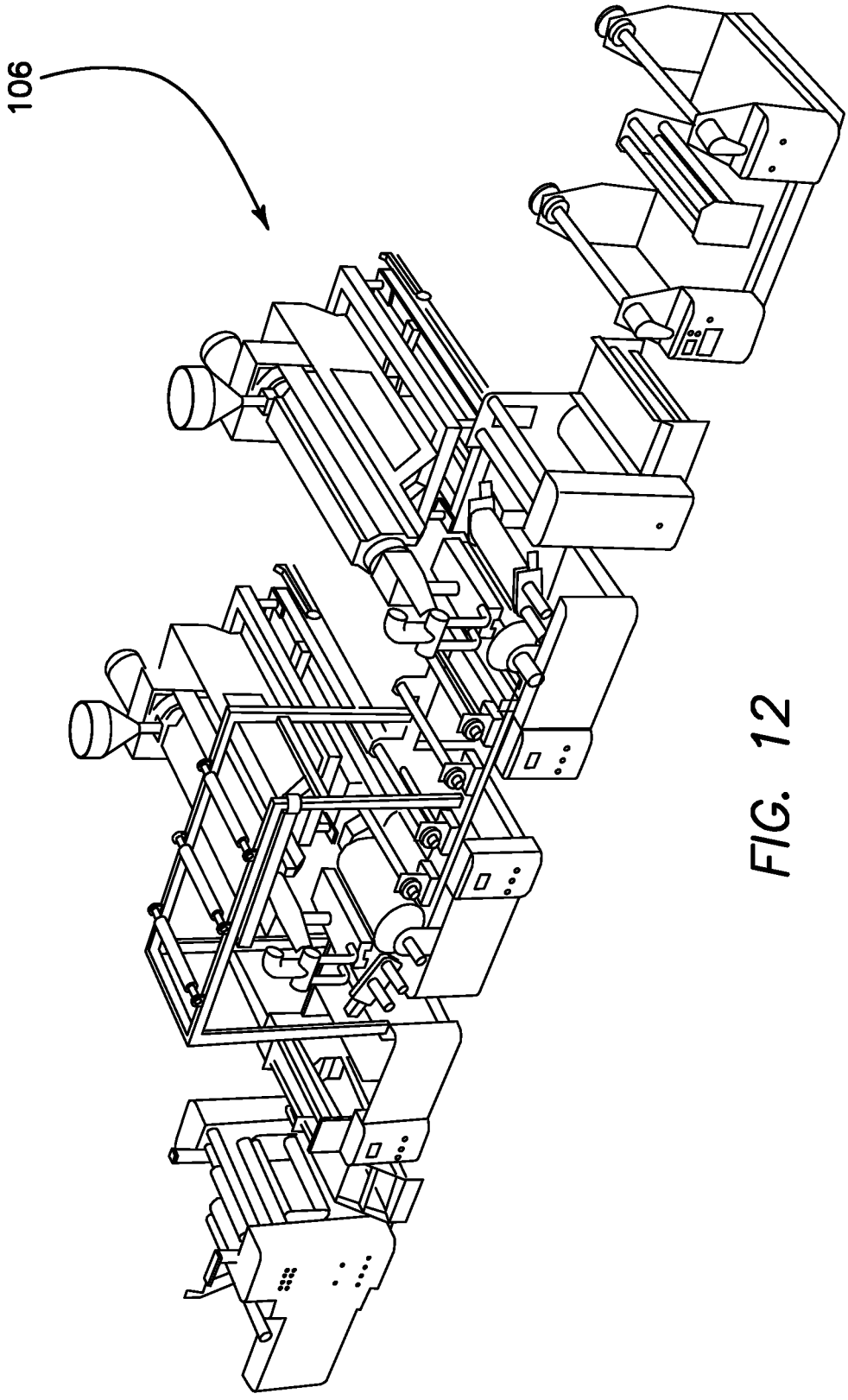



FIG. 12

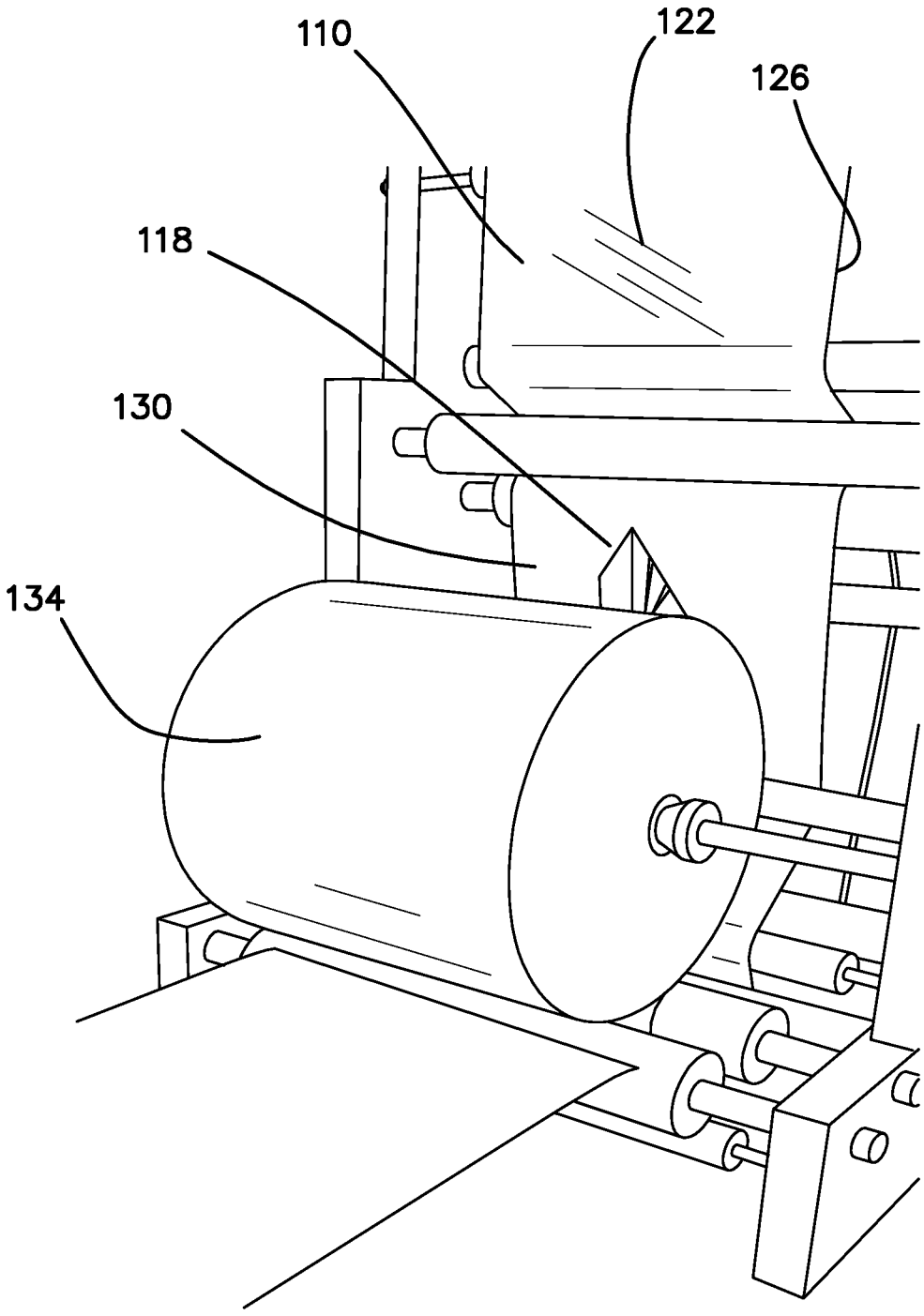



FIG. 13

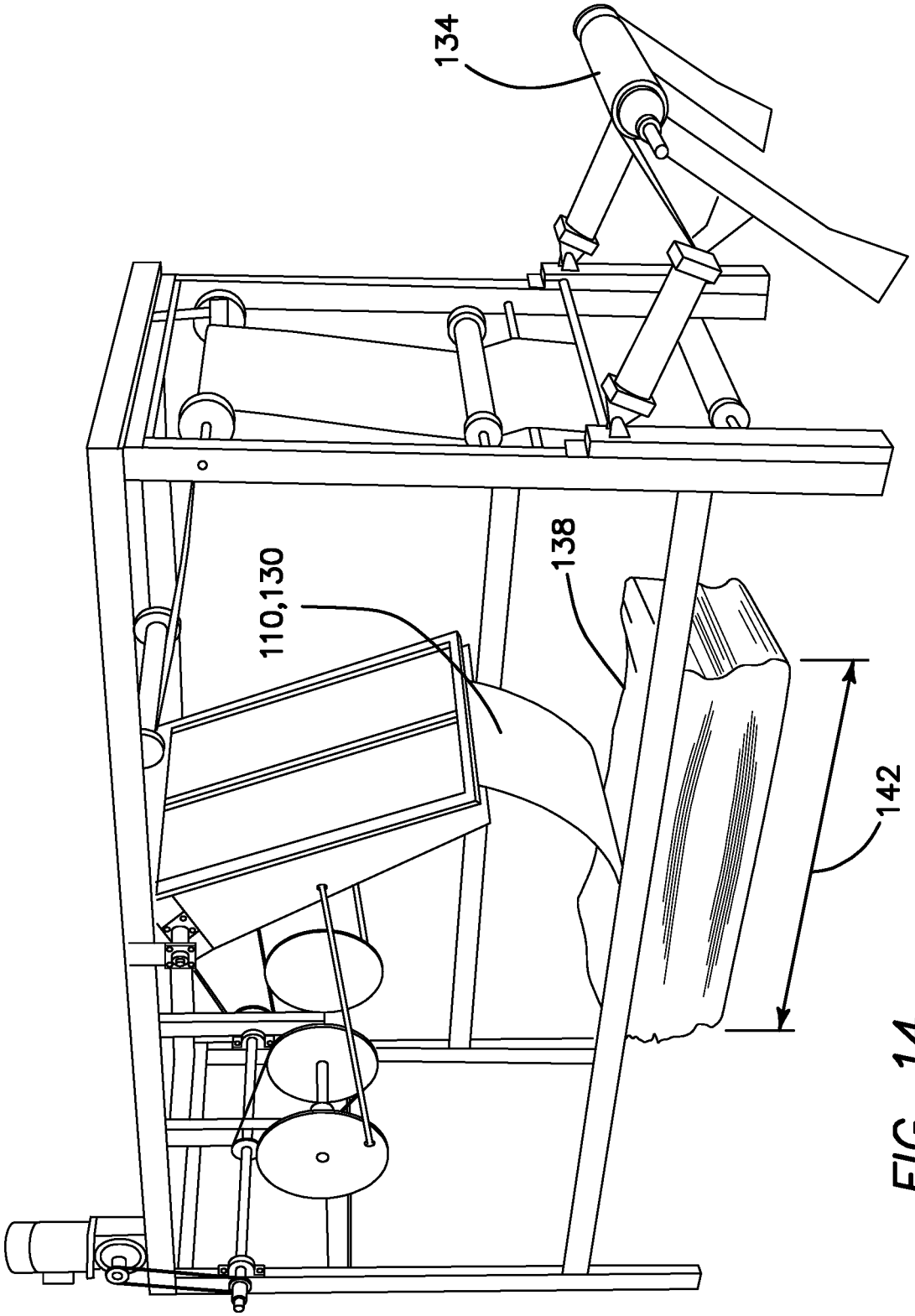
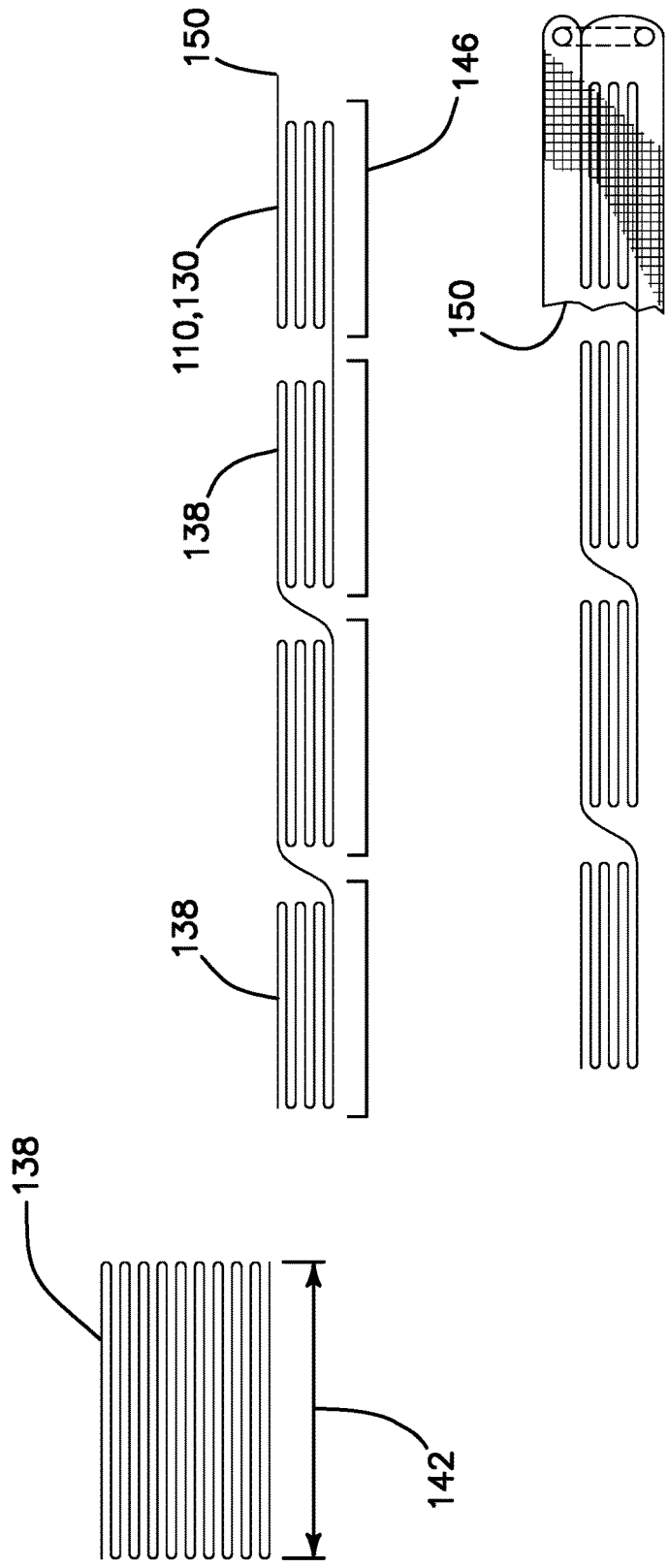



FIG. 14



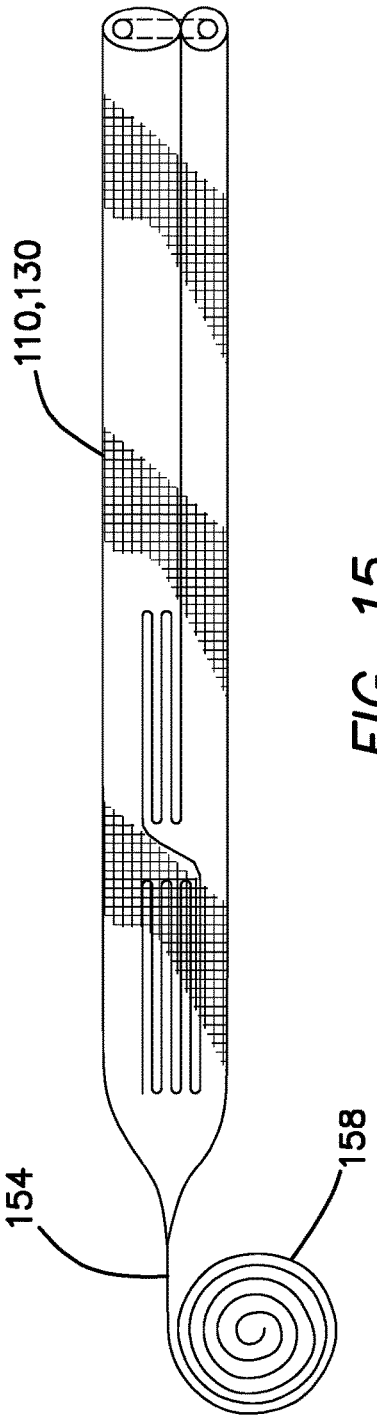




FIG. 15

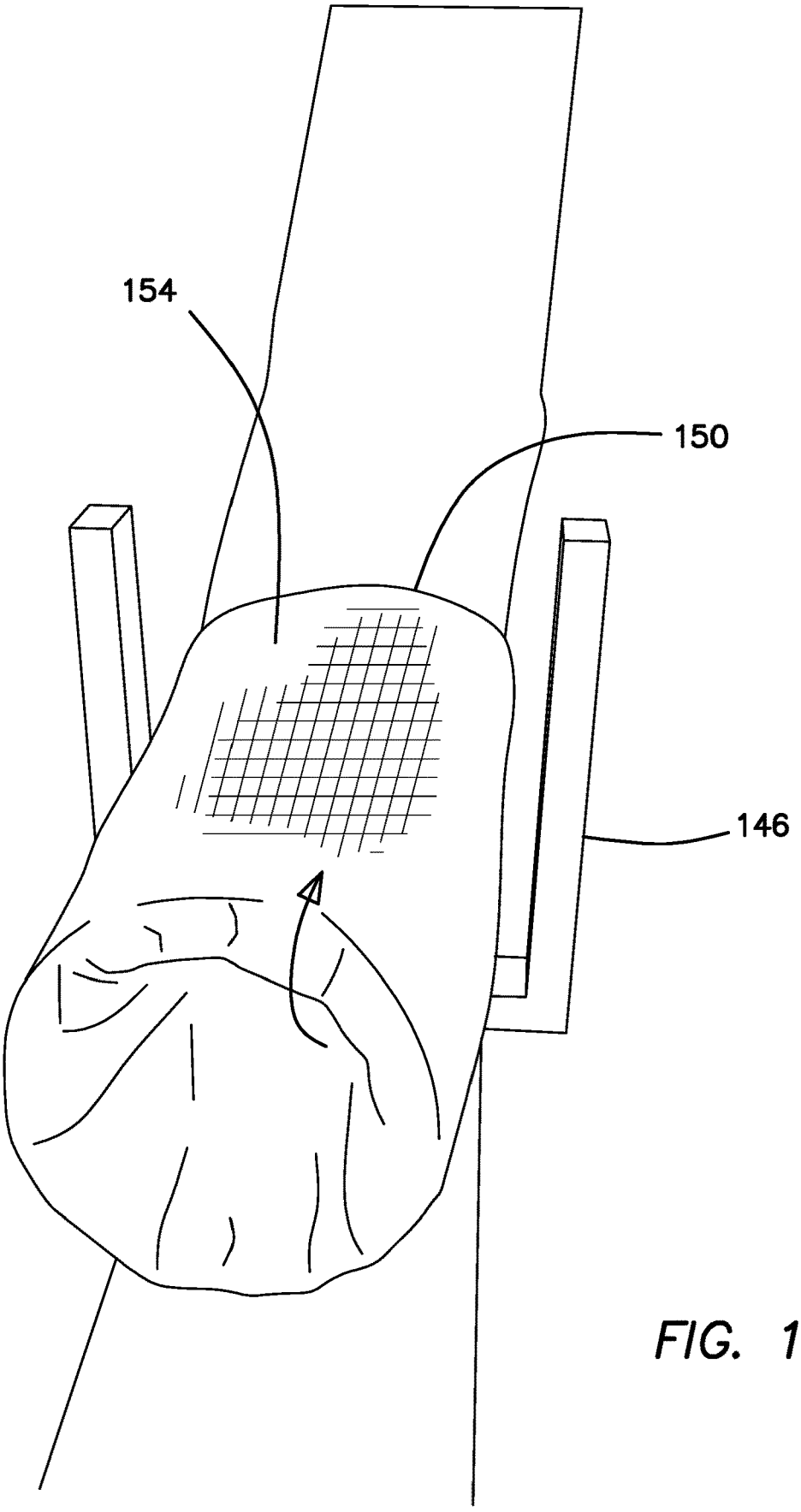



FIG. 16

# WOVEN IRRIGATION TUBING, APPARATUS AND METHOD OF MAKING SAME

## RELATED APPLICATIONS

**[0001]** The instant application is a continuation of Application No. PCT/US19/50714, filed Sep. 12, 2019 and currently pending, which takes priority from U.S. Provisional Application No. 62/854,555, filed May 30, 2019 and now expired.

## FIELD OF INVENTION

**[0002]** This invention relates to the field of crop irrigation and more specifically to recyclable woven plastic irrigation tubing.

## BACKGROUND OF THE INVENTION

**[0003]** Various methods have been developed for crop irrigation. Many of these methods involve aerial spraying of water. Spraying irrigation systems have been found to lose as much as 40% of the water sprayed due to evaporation. Drip style irrigation systems have been developed which work with an inclined and furrowed field in which an irrigation tube with spaced drip openings is disposed orthogonally to the furrows and water is pumped into the tube. The amount of pressure which the tubing can accommodate relates to the size of the field that can be irrigated by a single tube. Early irrigation tubing systems were limited to pressures of approximately one foot of head. As this type of irrigation tubing has a finite life, it is desirable that the tubing material be recyclable. While the early tubing systems used polyethylene plastic that is recyclable, later designs the can accommodate higher pressures have been made with polyethylene plastic which is not recyclable. The present invention addresses these problems by providing an irrigation tubing system that can accommodate substantially higher pressures while being manufactured of completely recyclable materials.

**[0004]** It is an objective of the present invention to provide an irrigation tubing system that can accommodate higher operating pressures than presently available systems. It is a further objective to provide a system that has a longer useful life than presently available systems. It is a still further objective of the invention to provide tubing that is easily and economically recyclable. Finally, it is an objective of the present invention to provide an irrigation tubing system is inexpensive to manufacture and easily packaged and shipped.

**[0005]** While some of the objectives of the present invention are disclosed in the prior art, none of the inventions found include all of the requirements identified.

## SUMMARY OF THE INVENTION

**[0006]** The present invention addresses all of the deficiencies of prior art woven irrigation tubing inventions and satisfies all of the objectives described above.

## PRODUCT SPECIFICATION

**[0007]** A typical embodiment of the Woven Irrigation Tubing is described below:

Diamond pipe is a woven, extrusion coated & laminated tube made of LLDPE, HDPE and LDPE.

It is used to move water at 2000 GPM.

**[0008]** Finished diameter 15" (381 mm)+/−⅛"

**[0009]** Lay-flat 23.5" (599 mm), wound on a 3" ID, ¼" thick, 25" wide PVC Core.

**[0010]** Length of wound roll 2640' (805 m+5/−0)+5/−0 meters

**[0011]** Three Layer Structure with UV protection.

**[0012]** Inside layer 20 gsm white LLDPE+/−2 gsm

**[0013]** Middle layer 20 gsm White LDPE+/−2 gsm

**[0014]** Outside layer 86 gsm 10 thread/inch, oriented HDPE woven seamless fabric+/−2 gsm

These present specifications are not meant to limit the configuration or make-up of the Woven Irrigation Tubing. Similar tubing of a 10" diameter is currently under development and other sizes are contemplated.

### Manufacturing Steps

**[0015]** 1) Manufacturing tape for woven outer tubing cover

**[0016]** a) Melting High Density Polyethylene (HDPE) resin

**[0017]** b) Monitoring pressure and flow with an extruder

**[0018]** c) Extruding the melted resin through a flat die to form a sheet

**[0019]** d) Cooling the extruded sheet in a quenching tank

**[0020]** e) Slitting the cooled sheet with a slitter to form the tape

**[0021]** f) Stretching the tape along its length using a tentering frame machine to increase longitudinal tape strength

**[0022]** g) Winding the stretched tape onto storage bobbins with a first winding machine

2) Weaving of outer tubing cover

**[0023]** a) Loading filled storage bobbins onto loom unwind stations

**[0024]** b) Threading each tape on the storage bobbins through a circular loom

**[0025]** c) Using the circular loom to weave the tape from the storage bobbins into a continuous woven seamless tube

**[0026]** d) Flattening the woven tube with a tubing flattener

**[0027]** e) Winding the woven tube onto a master storage roll with a second winding machine

3) Extrusion coating/laminating

**[0028]** a) Using an extrusion coating lamination apparatus to coat a molten middle layer of Low Density Polyethylene (LDPE) resin on the upper and lower surfaces of the flattened, woven tube and laminating an inside layer of Linear Low Density Polyethylene (LLDPE) film onto said middle layer of LDPE, forming upper and lower LLDPE layers

**[0029]** b) Winding the coated and laminated woven tube onto a roll with a third winding machine

**[0030]** c) Optionally unwinding tube from the roll, printing a logo or other information on at least one of the upper and lower LLDPE layers

**[0031]** d) Winding the printed tube onto rolls with a fifth winding machine

4) Reversing and winding of the printed tube

**[0032]** a) Unwinding the coated and laminated woven printed or unprinted tube from the roll and folding into linked stacks of a first predetermined size

**[0033]** b) Positioning the linked stacks on a series of support cradles

**[0034]** c) Opening a distal end of the tube and turning the tube back on itself

**[0035]** d) Pulling the opened end of the tube over the stacks and the cradles supporting them, turning the tube inside out

**[0036]** e) Winding the reversed tube onto a roll with a fourth winding machine

**[0037]** f) Covering the roll with a protective layer for storage and transport

**[0038]** An appreciation of the other aims and objectives of the present invention and an understanding of it may be achieved by referring to the accompanying drawings and the detailed description of a preferred embodiment.

## DESCRIPTION OF THE DRAWINGS

**[0039]** FIG. **1** is a cutaway perspective view of the preferred embodiment of the invention illustrating inner, middle and outer woven layers of the irrigation tubing;

**[0040]** FIG. **2** is a perspective view of an extruder and quenching tank used for fabrication of HDPE tape;

**[0041]** FIG. **3** is a close-up perspective view of the quenching tank and cooled extruded sheet;

**[0042]** FIG. **4** is a perspective view of a slitting machine for fabrication of the tape from the extruded sheet;

**[0043]** FIG. **5** is a perspective view of a tentering frame used to stretch the tape along its length;

**[0044]** FIG. **6** is a perspective view of the tape being wound on storage bobbins;

**[0045]** FIG. **7** is perspective view of the bobbins loaded on a storage cart;

**[0046]** FIG. **8** is a perspective view of the bobbins loaded on loom unwind stations and threaded through a circular loom;

**[0047]** FIG. **9** is a perspective view of the circular loom weaving an outer covering for the irrigation tubing from the HDPE tape;

**[0048]** FIG. **10** is perspective view of a winder creating a master roll of flattened tubing for lamination;

**[0049]** FIG. **11** is a side elevational schematic illustrating lamination of the woven tubing with molten LDPE and a LLDPE layer;

**[0050]** FIG. **12** is a perspective view of the extrusion coating lamination line;

**[0051]** FIG. **13** is a perspective view of equipment for unwinding, printing and rewinding the laminated tubing;

**[0052]** FIG. **14** is a perspective view of equipment for unwinding, folding and stacking the laminated tubing;

**[0053]** FIG. **15** is schematic side elevational view of the process of turning the tubing inside out over itself and the stacked tubing; and

**[0054]** FIG. **16** is a perspective view of the process shown in FIG. **15**.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

**[0055]** (1) FIG. **1** illustrates a typical embodiment of the woven irrigation tubing **10** of the present invention. The tubing **10** is a woven, extrusion coated & laminated tube made of HDPE **14**, LDPE **18** and LLDPE **22**. It is used to move water at 2000 GPM. The tubing **10** has a finished diameter 15" (381 mm)+/−⅛". The tubing **10** has a lay-flat width **22** of 23.5" (599 mm) and is wound on a 3" ID, ¼" thick, 25" wide PVC Core **26**. The typical length of a wound roll **26** is 2640' (805 m+5/−0)+5/−0 meters. The tubing **10** has a three layer structure with UV protection **30**. The inside layer **34** is 20 gsm white LLDPE **22**+/−2 gsm. The middle layer **38** is 20 gsm White LDPE **18**+/−2 gsm. The outside layer **42** is 86 gsm, 10 thread/inch, oriented HDPE **14** woven seamless fabric+/−2 gsm.

**[0056]** (2) FIGS. **2-16** illustrate the steps for manufacturing the woven irrigation tubing **10**. As illustrated in FIGS. **2-7**, Manufacturing tape **46** for outside layer **42** includes the following: Melting High Density Polyethylene (HDPE) resin **14**. Using instruments **48** to monitor pressure and flow with an extruder **50**. Extruding the melted resin **14** through a flat die **54** to form a sheet **58** of HDPE resin **14**. Cooling the extruded sheet **58** in a quenching tank **62**. Slitting the cooled sheet **58** with a slitter **66** to form the tape **46**. Stretching the tape **46** along its length **70** using a tentering frame machine **74** to increase longitudinal tape strength. Winding the stretched tape **46** onto storage bobbins **78** using a first winding machine **52**.

**[0057]** As illustrated in FIGS. **8-10**, Weaving of outer tubing cover includes the following: Loading filled storage bobbins **78** onto loom unwind stations **82**. Threading each tape **46** on the storage bobbins **78** through a circular loom **86**. Using the circular loom **86** to weave the tape **46** from the storage bobbins **78** into a continuous woven seamless tube **90**. Flattening the woven tube **90** using a tubing flattener **88**. Winding the woven tube **90** onto a master storage roll **94** using a second winding machine **92**.

**[0058]** (4) As illustrated in FIGS. **11-13**, Extrusion coating/laminating of the woven tube **90** includes the following: Coating upper **98** and lower **102** surfaces of the flattened, woven tube **90** with molten Low Density Polyethylene (LDPE) resin **18**. Laminating a layer of Linear Low Density Polyethylene (LLDPE) film **22** onto the molten LDPE resin **18** on each of the upper **98** and lower **102** surfaces of the woven tube **90** using an extrusion coating lamination apparatus **106**. Winding the coated and laminated woven tube **110** onto a roll **114** using a third winding machine **116**. Optionally unwinding tube **110** from the roll **114**, printing a logo or other information **118** on at least one of the upper **122** and lower **126** LLDPE layers. Winding the printed tube **130** onto rolls **134** using a fifth winding machine **132**.

**[0059]** (5) As illustrated in FIGS. **14-16**, Reversing and winding of the tube **110** or printed tube **130** includes the following: Unwinding the coated and laminated woven tube **110**, **130** from the roll **134** and folding it into linked stacks **138** of a first predetermined size **142**.

**[0060]** Positioning the linked stacks **138** on a series of support cradles **146**. Opening a distal end **150** of the tube **110**, **130** and turning the tube **110**, **130** back on itself. Pulling the opened distal end **150** of the tube **110**, **130** over the stacks **138** and the cradles **146** supporting them. Winding the reversed tube **154** onto a roll **158** using a fourth winding machine (not shown). Covering the roll **158** with a protective layer (not shown) for storage and transport.

**[0061]** The woven irrigation tubing **10**, apparatus and method of making same have been described with reference

to particular embodiments. Other modifications and enhancements can be made without departing from the spirit and scope of the invention.

**1**. An apparatus for making woven irrigation tubing, comprising:

HDPE resin;

an extruder for said HDPE resin;

instruments to monitor pressure and flow rates for said extruder;

a flat die for said extruder suitable for forming extruded sheets of HDPE resin;

a quenching tank for cooling said extruded sheets of HDPE resin;

a slitter for slitting said extruded sheets of HDPE resin into tape;

a tentering frame machine for stretching said tape along its length to increase longitudinal tape strength of said tape;

a first winding machine and storage bobbins for winding said tape onto said storage bobbins for further processing;

loom unwind stations for positioning said wound storage bobbins prior to weaving;

a circular loom for weaving said tape stored on said storage bobbins into a continuous woven seamless tube;

a tubing flattener for flattening said woven seamless tube;

a second winding machine for winding said flattened woven seamless tube onto a master storage roll;

LDPE resin;

LLDPE film;

an extrusion coating laminating apparatus for coating a middle layer of LDPE onto upper and lower surfaces of said flattened woven seamless tube, forming upper and lower LDPE layers and for laminating an inside layer of LLDPE film onto said middle layer of LDPE, forming upper and lower LLDPE layers;

a third winding machine for winding said coated and laminated woven tubing onto a roll;

a series of support cradles for supporting linked stacks of said coated and laminated woven tube from an unwound roll that have been folded into said linked stacks of a first predetermined size so that the tube may be pulled over itself and turned inside out, forming a reversed tube; and

a fourth winding machine for winding said reversed tube onto a roll.

**2**. The apparatus for making woven irrigation tubing, as described in claim **7**, further comprising:

a printer for printing a logo or other information on at least one of said upper and lower LLDPE layers, forming a printed tube; and

a fifth winding machine for winding the printed tube onto a roll.

**3**. A method of making woven irrigation tubing, comprising the steps of:

providing HDPE resin;

providing an extruder with a flat die;

melting said HDPE resin in said extruder, forming a melted resin;

monitoring pressure and flow of said melted resin in said extruder;

extruding said melted resin through said flat die to form an extruded sheet;

providing a quenching tank:

cooling said extruded sheet in said quenching tank;

providing a slitter;

slitting said extruded sheet in said slitter to form a tape;

providing a tentering frame machine;

stretching said tape using said tentering frame machine to increase longitudinal strength of said tape, forming a stretched tape;

providing at least one storage bobbin and a first winding machine;

winding said stretched tape onto said at least one storage bobbin;

providing at least one loom unwind station;

loading said at least one storage bobbin onto said at least one loom unwind station;

providing a circular loom;

threading said stretched tape on said at least one storage bobbin through said circular loom;

weaving said stretched tape into a continuous woven seamless tube using said circular loom;

providing a tubing flattener;

flattening said continuous woven seamless tube;

providing a second winding machine for winding said flattened woven seamless tube onto a master storage roll;

providing LDPE resin;

providing LLDPE film;

providing an extrusion coating laminating machine;

laminating a middle layer of LDPE onto upper and lower surfaces of said flattened woven seamless tube, forming upper and lower LDPE layers and laminating an inside layer of LLDPE film onto said middle layer of LDPE, forming upper and lower LLDPE layers;

providing a third winding machine;

winding said coated and laminated woven tubing onto a roll;

providing a series of support cradles;

supporting linked stacks of said coated and laminated woven tube from an unwound roll that have been folded into said linked stacks of a first predetermined size so that the tube may be pulled over itself and turned inside out, forming a reversed tube;

providing a fourth winding machine; and

winding said reversed tube onto a roll.

**4**. The method of making woven irrigation tubing, as described in claim **9**, further comprising the steps of:

providing a printer;

printing a logo or other information on at least one of said upper and lower LLDPE layers, forming a printed tube;

providing a fifth winding machine;

winding said printed tube onto a roll.

* * * * *